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ENVIRONMENTAL MANAGEMENT PROGRAM

LONG TERM RESOURCE MONITORING PROGRAM
UPPER MISSISSIPPI RIVER SYSTEM

VEGETATION WORKSHOP
AERIAL PHOTOGRAPHY INTERPRETATION

NOVEMBER 1990

U.S. FISH AND WILDLIFE SERVICE
ENVIRONMENTAL MANAGEMENT TECHNICAL CENTER
575 LESTER AVENUE
ONALASKA, WISCONSIN 54650

95-040441

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VEGETATION WORKSHOP
AERIAL PHOTOGRAPHY INTERPRETATION
November 13-15

OBJECTIVES:

OVERALL - Become familiar and comfortable with aerial photographs so they become an everyday tool in the vegetation specialists' "tool kit". Under this overall objective are four key areas:

1. Become familiar with concept and use of scale.
2. Develop ability to accurately locate photos/field data on ground and on maps.
3. Learn basics of photo interpretation and vegetation mapping.
4. Learn to see in apparent three dimensions on photos.

Tuesday, November 13
Instructor: Tom Owens

8:00-9:00 a.m. I. Theory and Applications of Remote Sensing
- A. Definition of remote sensing
- B. Brief history
- C. Present day remote sensing
  - 1. The electromagnetic spectrum
  - 2. Active versus passive systems

9:00-10:00 a.m. D. Remote sensing applications for UMRS (M. Laustrup)
  - 1. Landcover/landuse mapping - an overview
  - 2. Monitoring plant communities

10:00-10:15 a.m. BREAK

II. Aerial Photography

10:15-11:00 a.m. A. Formats
  - 1. Cameras and lenses
  - 2. Film

B. Scale

11:00-12:00 a.m. 1. Determination of scale (EXERCISES)
  - 2. Uses of various scales

12:00-1:00 p.m. LUNCH

1:00-2:00 p.m. 3. Measuring areas (EXERCISES)

2:00-2:30 p.m. C. Stereo viewing
- D. Other applications

2:30-3:00 p.m. E. Acquisition of aerial photos

3:00-3:15 BREAK

III. Introduction to Photo Interpretation

3:15-4:00 p.m. A. Definition
- B. Photo preparation (EXERCISES)
  - 1. Indexing - locating photos on maps
  - 2. Preparation for PI

4:00-5:00 p.m. C. Signature
    1. Color/tone
    2. Texture
    3. Pattern
    4. Shape
    5. Size
    6. Location

Wednesday, November 14
Instructors: Tom Owens, Rory Vose

III. Introduction to Photo Interpretation (Continued)
8:00-9:00 a.m. D. Identification of objects & signatures (EXERCISES)
9:00-10:00 a.m. E. Ground-truth
    1. Importance
    2. Considerations
  F. Classification systems
    1. Significance
    2. Minimum mapping unit
  G. Stratification
  H. Cartography - transferring photo data to base maps

10:00-10:15 a.m. BREAK

IV. Photo Interpretation Workshop
10:15-11:00 a.m. A. Perspectives of a River Rat (R. Vose)
11:00-12:00 a.m. B. Handling troublesome areas
    1. The concept of boundaries
    2. Areas of mixed vegetation
    3. Areas that can't be identified on photos
  C. Drawing and labeling polygons
  D. Cartographic errors

12:00-1:00 p.m. LUNCH

1:00-5:00 p.m. D. Work on your own photos

Thursday, November 15
Instructor: Tom Owens

8:00-12:00 a.m. IV. Photo Interpretation Workshop (Continued)
  D. Work on your own photos

V. Wrap-up/Questions

PREFACE

This manual was prepared for the Upper Mississippi River System Long Term Resource Monitoring Program. The Upper Mississippi River System is composed of the navigable reaches of the Upper Mississippi, Illinois, Kaskaskia, Black, St. Croix, and Minnesota Rivers. The Long Term Resource Monitoring Program is a part of the Environmental Management Program authorized under the Water Resources Development Act of 1986 (Public Law 99-662).

This manual was prepared by Tom Owens, Remote Sensing Specialist with TGS Technology, Inc., Fort Collins, Colorado, and is intended to supplement the Aerial Photography Interpretation Workshop of November 13-15, 1990, La Crosse, Wisconsin. The workshop's objective is to give Long Term Resource Monitoring Program field personnel the training to use aerial photographs as part of trend analysis.

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VEGETATION WORKSHOP
AERIAL PHOTOGRAPHY INTERPRETATION
NOVEMBER 13-15
ENVIRONMENTAL MANAGEMENT TECHNICAL CENTER - LA CROSSE, WI

INTRODUCTION

This workshop's objective is to give Long Term Resource Monitoring (LTRMP) field personnel the training to use aerial photographs in their everyday work. By the end of the workshop field personnel will be able to use aerial photos to aid in locating where they are in the field, to help locate field plots and transects on base maps, to be able to identify and map objects and vegetation types on photos, and determine photo scale, and to measure objects on photos.

The Instructor's working assumption is that no one has any knowledge of aerial photography, and so we must begin with the basics. If anyone in the workshop has some knowledge of aerial photography, please remain patient until everyone is at the same knowledge level.

THEORY AND APPLICATION OF REMOTE SENSING

The objective of this section is to give you a **brief** overview of the remote sensing field, so field personnel will able to understand and appreciate the remote sensing projects Environmental Management Technical Center (EMTC) is working on, as well as the mapping projects EMTC is sponsoring at the National Ecological Research Center (NERC), in addition to being able to place the role of aerial photography in its proper context in the larger field of remote sensing.

DEFINITION OF REMOTE SENSING

Remote sensing is "the acquisition of information about an object without physical contact" (ASP Manual of Remote Sensing, 1983). This is a broad definition and could include the remote sensing of objects with our eyes or ears or noses, but the term remote sensing usually refers to the gathering and processing of information about the earth's environment through technical means, with the further restriction of using aircraft or satellites as platforms to acquire data.

BRIEF HISTORY

The first important event in the history of remote sensing is the development of the photographic process by Louis Daguerre in 1839, in which images could be exposed and fixed on paper. The photographic process developed so rapidly thereafter that by the end of the nineteenth century the basis of modern photography had been established.

Not being content with taking photographs from the ground, photographers soon took to balloons. The first known aerial photograph was taken in 1859 by Tournachon near Paris. As with many technological inventions, wartime needs spurred the development of aerial photography. During the Civil War Union soldiers took photographs of Confederate positions from balloons.

Airplanes greatly stimulated aerial photography because they were more reliable and controllable platforms for photography than balloons . By World War II the principal combatants, particularly the Germans, had excellent photo reconnaissance and interpretation abilities. Many pilots, photographers, and interpreters trained in the War continued on in civilian capacities. WWII not only stimulated the art and science of aerial photography and interpretation, but also prompted the development of other aerial reconnaissance devices, including thermal infrared and active microwave (radar) devices.

During the 1950's color infrared (IR) photography, originally developed as a military reconnaissance tool to detect camouflaged sites, was found to be very useful in the plant sciences.

In the early 1960's the term "remote sensing" was coined by geographers at the Office of Naval Research to include the development of non-photographic systems being developed, especially satellite carried sensors. The United States was a pioneer in early spaced based remote sensing activities, beginning with meteorological satellites in the early 1960's. The first satellite specifically designed to collect data of the earth's resources was ERTS-1, later renamed Landsat-1, was launched in 1972.

PRESENT DAY REMOTE SENSING

That brings us up to the present time. Today many countries have satellites, including the Soviet Union, which has long been active in remote sensing, France, India, Brazil, China, and Japan. These satellites use multi-spectral scanners to monitor earth resources, agriculture, vegetation, soils, land use changes, weather, as well as military applications. Other technologies, such as radar and thermal scanners are commonly used for geological, hydrological, and climatological applications.

Under the high tech sensors aerial photography still plays a major role in remote sensing. Federal, state, and private organizations are still flying massive amounts of aerial photography for many uses, including photogrammetric and engineering uses (e.g., highway construction), crop monitoring, forestry uses, wildlife habitat monitoring, vegetation mapping, geological mapping, archeological uses; the list is endless.

While new technology is developing rapidly, the proven methods of aerial photography and interpretation are still being used. Perhaps the new technologies will be able to replace the standard methods for detailed mapping, but for the foreseeable future these methods are still the best.

The Electromagnetic Spectrum

Energy is spread in the form of waves by electromagnetic radiation (EMR) at the "speed of light" (3×10^8 m/s), directly through free space, or indirectly by reflection and re-radiation to the remote sensor. Changes in EMR , when remotely sensed, become a valuable source of data for interpreting properties of the source bodies.

EMR is emitted within the electromagnetic spectrum (EMS), which ranges from gamma rays with the shortest wavelength of 0.03 Angstroms (1 Angstrom = 10^{-8} cm) to the longest, with wavelengths in the thousand of kilometers (Figure 1).

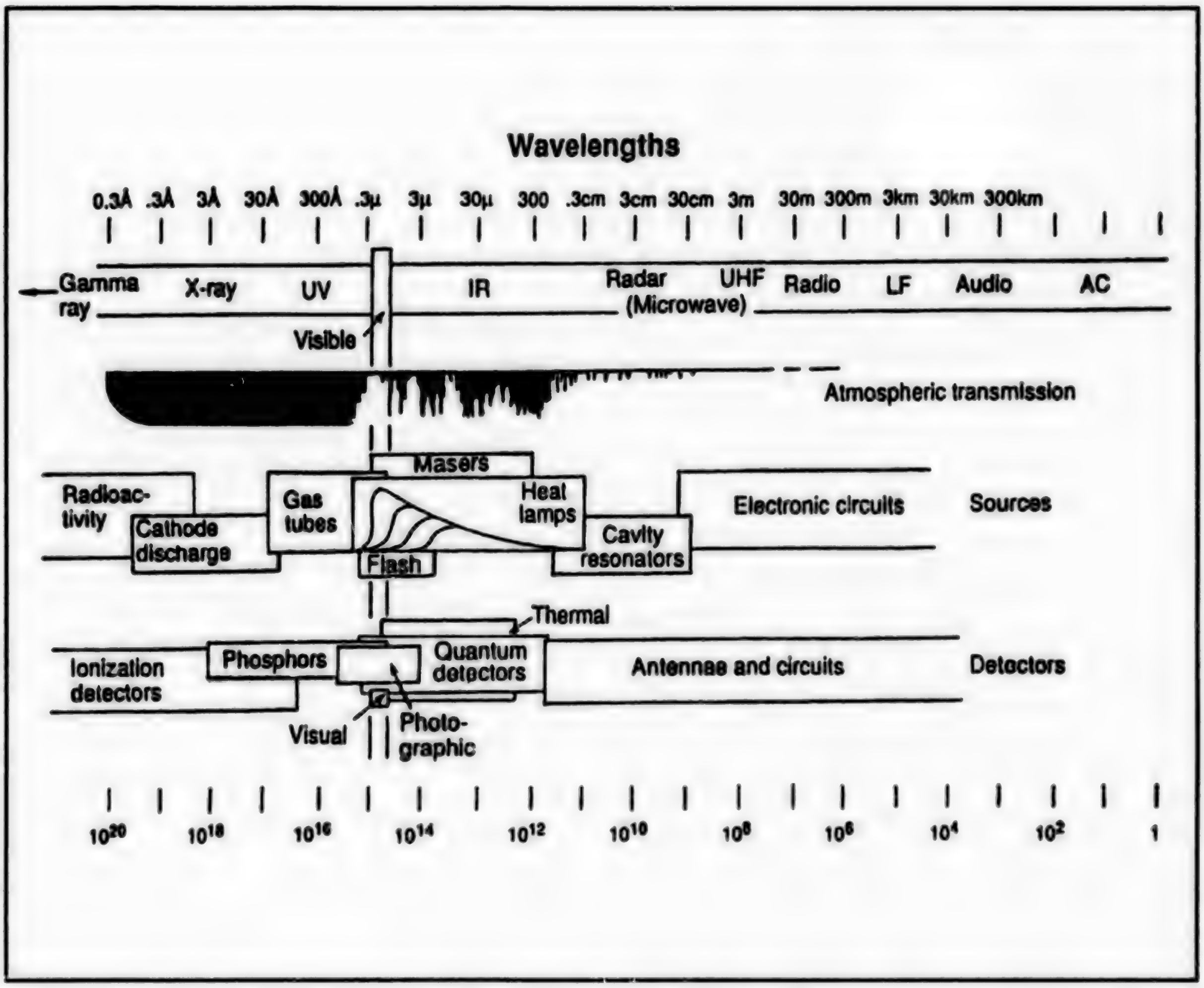

Figure 1. Electromagnetic Spectrum Wavelength

The major points of interest in Figure 1 are:

- The visible portion is a very small part of the EMS, which corresponds to the peak region of luminescence of the sun. In fact the bulk of the sun's energy is emitted in the ultraviolet (UV), visible, and IR portions of the spectrum.

- The atmosphere is opaque to all of the shorter wavelengths of EMR, variably transparent in the visible and IR regions, and totally transparent in the longest wavelengths.

- The visible, IR, and microwave sections of the EMS are mainly used for remote sensing, although some UV work has been done.

- Near-visible IR does not heat, but produces EMR which is a product of reflected sunlight (same as visible EMR), while thermal IR, which has a wavelength of 30 microns, is produced by emitted (heat) EMR. Since thermal IR has a much longer wavelength, its resolution is much poorer.

- At wavelengths longer than 1 mm sophisticated electronic receivers and antennas are required to detect EMR, also the resolution is extremely poor, but even clouds and rain are transparent to radar.

Some types of EMR and their remote sensing applications are listed below in Table 1.

Table 1. Remote Sensor types and Applications

Remote Sensors	Part of EM Spectrum Utilized	Comments
Geiger Counters	<0.03 0 100 Å	Measurement of emitted natural radiation.
Cameras		
Using conventional B&W and color film	4,000 - 7,000 Å (0.4 - 0.7 μm)	B&W film for high spatial detail.
Using infrared film (B&W and IR color)	6,000 - 9,000 Å (0.6 - 0.9 μm)	Improved spatial detail through contrast greater reflectance gradients useful for vegetation surveys.
Multispectral units	3,000 - 9,000 Å (0.3 - 0.9 μm)	Individual narrow band scenes available with multi-camera systems.
Laser radar	4,000 - 11,000 Å	Monochromatic active system for measuring backscattered EMR from atmosphere.
Radars	1 mm - 0.8 m	Narrow band active system. Both analog data and imagery available.
Radiometers (microwave)	1 mm - 00.8 m	Passive systems. Both analog and imagery available.

The portions of the EMS we are most interested in are the visible and near-visible IR portions, which is from 0.4 microns (1 micron = 10^{-4} mm) to 0.7 microns for the visible segment of the EMS and 0.7 to 1.1 microns for the near-visible IR. See Figure 2 below for the visible and near-visible portion of the EMS.

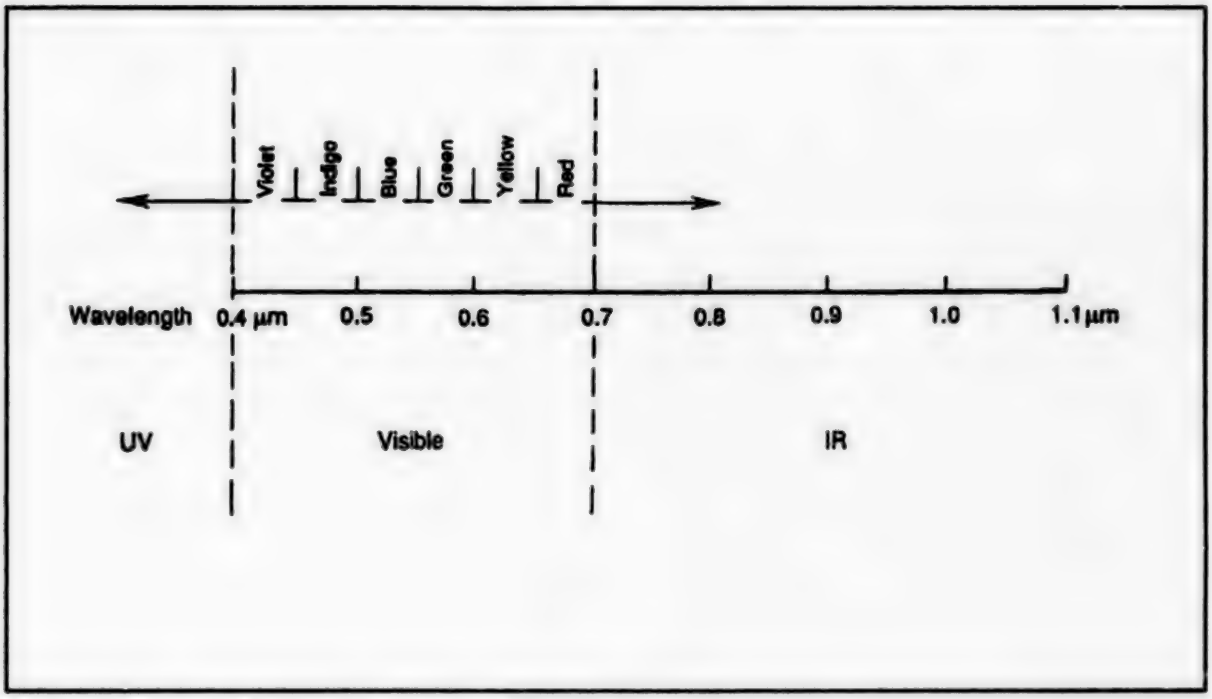

Figure 2. Visible and IR Portion of Spectrum

In the visible and IR portions of the EMS, there are many atmospheric interactions caused by particles and moisture in the atmosphere. Scatter, absorption, and refraction are atmospheric effects which reduce EMR transmission. As a general rule, the larger the size of the objects in the atmosphere in relation to the wavelength, the more the scattering and absorption. Thus longer wavelengths are transmitted through the atmosphere better than are shorter wavelengths.

Once sunlight penetrates our atmospheric soup it interacts with the surface materials, whether they are vegetation, bare soil, water, or concrete. Some of the EMR is absorbed and some is reflected back into the atmosphere. It is this reflected EMR that is detected by remote sensing system, and the variations in the target materials causes variation in the reflected EMR that allows us to distinguish between different types of objects.

In leaves of vegetation pigment molecules, especially chlorophyll, carotenes, and xanthophyll, are the main factor affecting reflectance and absorption of visible EMR. These pigment molecules directly absorb energy from incoming EMR at different wavelengths, which is used to initiate photosynthesis. The EMR that is not absorbed is reflected or transmitted through the leaf. In the visible spectrum, vegetation appears green because it reflects green light and absorbs most of the red and blue light that strikes it. See Figure 3 below for spectral characteristics of Populus deltoides.

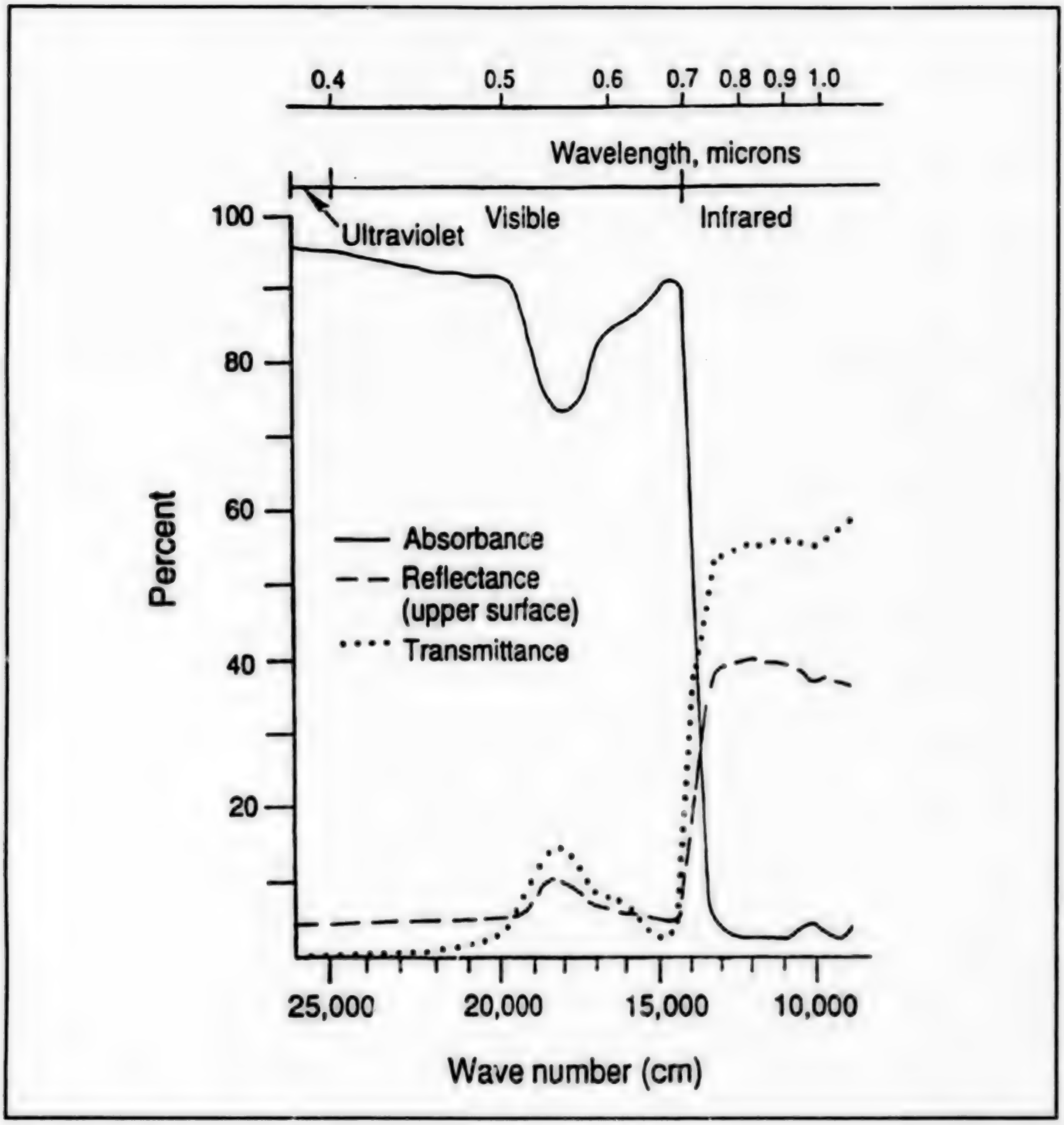

Figure 3. Spectral Characteristics

Active Versus Passive Remote Sensing Systems

Active systems record echoes of reflected EMR which they themselves produce (e.g., radar). Passive systems detect EMR that would be present whether or not the system was operating (e.g., photography, satellite imagery). See Figure 4 below.

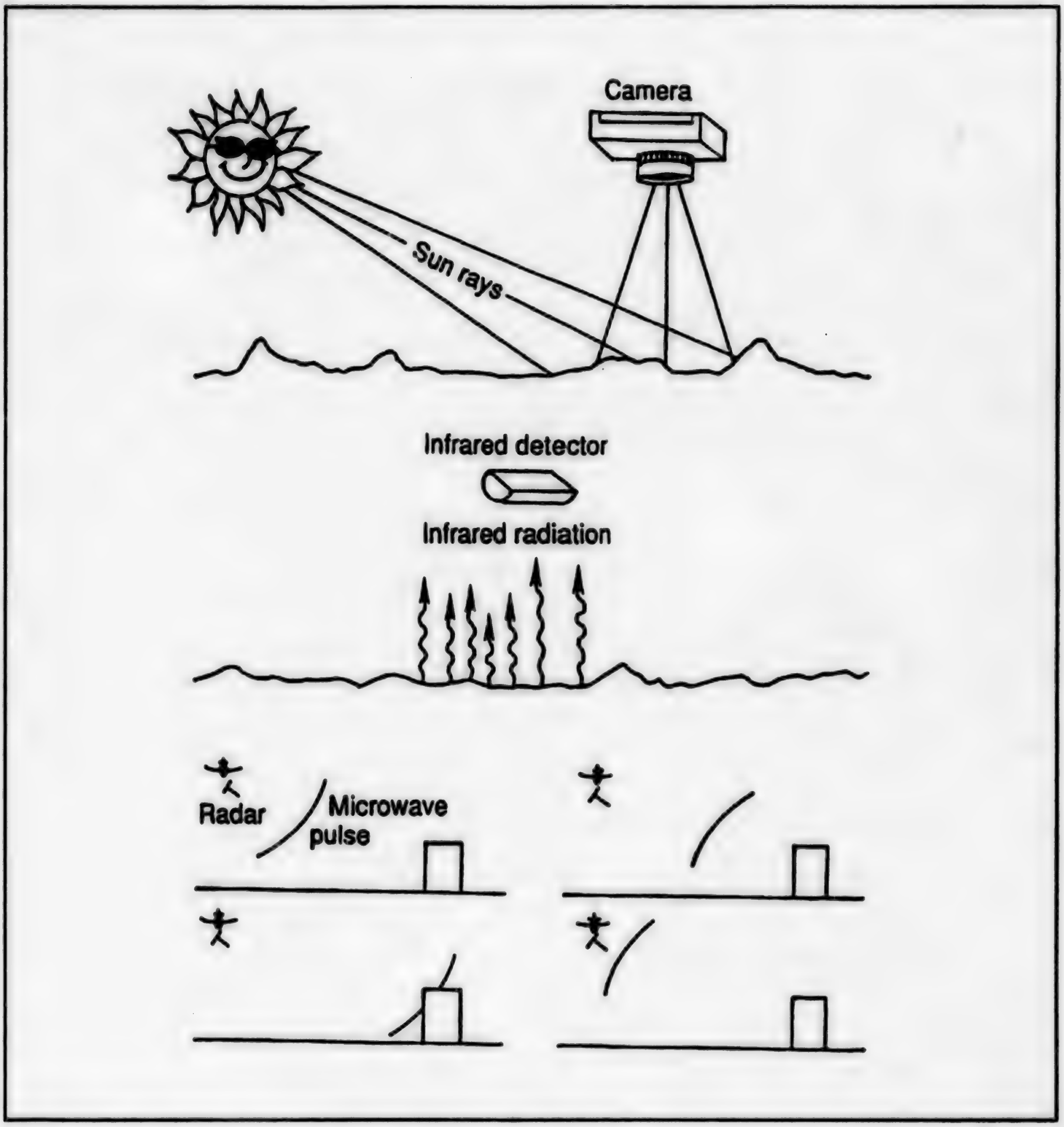

Figure 4. Difference between passive and active sensors.

Active systems produce their own energy, so they are independent of time of day for their use. Longer wavelengths of active systems penetrate fog, haze, and clouds with minimal signal loss. Rain and thick moisture laden clouds can attenuate the signal however. Also, longer wavelengths lessen the resolution possible. Side looking airborne radar operates independently of the clock and maintains constant image quality over extremely long ranges.

Passive systems are dependent upon time of day for use. Photography and satellite imagery are dependent upon sunlight. Thermal IR is most effective at night when temperatures differences between the objects of interest (e.g., large animals, roofs of buildings) and the surroundings are greatest. Photo systems need cloudless, haze free days. Camera systems possess the best resolution and give geometrically accurate representations. Thermal IR systems record minute temperature differences.

There is no one optimum sensor because the applications are so diverse See Table 2 below for comparison of three systems.

Table 2. Remote Sensor Comparison

Parameter	Camera	Infrared	Radar
Day/Night	5	10	10
Haze-fog Penetration	3	7	10
Cloud Penetration	1	2	9
Temperature Discrimination	2	10	1
Subsurface Detection	4	6	3
Stereo Capability	10	6	6
Geometric Fidelity	9	7	8
Long Range Capability	7	4	9
Ground Resolution	9	7	5
Interpretability of Imagery	9	6	6
Availability of Equipment	10	6	6

Poor = 0 Good = 10

The active remote sensing system in use today is radar, which emits and detects energy in the microwave region of the EMS (most systems currently operate at wavelengths between 0.86 and 3.3 cm). Early uses were to detect distance and direction of far objects, such as ships or airplanes. This had obvious military applications and by the beginning of WWII several countries had operable radar systems. In the early use of radar it was noted that objects in the surrounding environment produced a return to the receiver. This was known as ground clutter and military users assiduously worked to suppress these signals. As radar was declassified scientists from other disciplines realized the value of ground clutter returns. Once the value of these returns was recognized, the complex problem of systematic interpretation was addressed. Now radar is used extensively for many kinds of mapping, especially in areas of the world that have poor weather conditions, such as the Amazon basin.

Applications include geological mapping, surface mapping, drainage mapping, land use patterns, and weather.

There are many passive systems in use today. Photography is the most important system and will be covered in more detail later. Other passive systems include ultraviolet systems, thermal systems, electro-optical systems, and passive microwave systems.

The UV is the least investigated and used portion of the EMS (100 to 4000 angstroms). The earth's atmosphere absorbs UV radiation, specifically ozone. This allowed development of the ozone spectrophotometer in 1930 and the establishment of a world wide monitoring system of ozone. However, the relative opaqueness of the atmosphere to UV radiation makes standard remote sensing difficult.

The IR portion of the EMS is widely used today in remote sensing. Discussion of the near visible IR portion will be included in the photography section later, but the thermal IR portion (1.5 microns - 1 mm) will be addressed here. Military applications, such as heat seeking sensors, were early developments in thermal IR. Medical applications, such as skin thermographs, are used to detect such things as varicose veins or breast cancer. In standard remote sensing thermal IR is detected using scanners, which will be briefly discussed under the electro-optical section. Thermal IR scanners detect differences in heat radiation between the object of interest and its surroundings. Applications include detecting "hot spots" in forest fires, ice thickness in the St. Lawrence seaway to determine if the ice is thin enough for icebreakers to plow in the spring to allow navigation, detection of large animals, mapping of volcanic and hydrothermal phenomena, detection of heat loss through roofs, and detection of agricultural pests.

Electro-optical sensors detect reflected EMR and converts it to electrical impulses, which are then processed in various ways. Photo scanners track across the aircraft's flight path with rotating mirrors, the EMR is reflected onto a parabolic mirror, which reflects it to a solid-state detector. The output from the detector is amplified and modulated and recorded on film. The output looks similar to conventional photography, but is detecting EMR from non-visible portions of the EMS. Satellite scanners work in a similar way, except that the electronic data are not captured on film initially, but transmitted to earth receiving stations, and then processed. Landsat 4 has a multi-spectral scanner that detects EMR from 0.45 to 12.50 microns in six bands.

Passive microwave systems operate in the same portion of the EMS as radar, but only detect exterior energy. Applications include radio astronomy and temperature profile measurement of the atmosphere.

REMOTE SENSING APPLICATIONS FOR UMRS (Mark Laustrup)

AERIAL PHOTOGRAPHY

Formats

Cameras and Lenses. Mapping or large format cameras are the standard tool for aerial photography. The requirements of aerial mapping cameras are quite different from those of ordinary amateur cameras. The primary requirements are a lens of high geometric quality, and rapid film advancement. Aerial cameras must be capable of exposing a great number of photos rapidly to exacting specification in a rapidly moving aircraft. Single lens cameras are the most common mapping cameras, with a standard film size of 9 inches by 9 inches. The film is generally fixed during exposure, although more advanced cameras have a forward motion compensator to offset the aircraft's movement. Large format cameras are mounted in the plane's belly and shoot through a belly hole. Camera mounts include anti-vibration devices, crab and levelling controls. Advantages of large format cameras over small format cameras include large film size, which covers a large area, and high geometric consistency. Disadvantages include high cost, use of a highly trained photographer, and slow turn-around time for film processing. Mapping cameras are used for photogrammetric work and large scale resource surveys, such as the UMRS mapping project.

Small format cameras include 70 mm and 35 mm formats. Seventy mm cameras are usually Hasselblad cameras, and 35 mm cameras should be a high quality rugged camera such as Nikon. Motor drives, shutter cables, and large viewing screens are required to operate these systems in aerial photography. Small format cameras can be mounted in the plane's belly, or out a window. The advantages of small format systems over large format cameras include being relatively inexpensive, flexible, easier to operate, and having a quick turn-around for film processing. The disadvantages include small film area, lack of geometric consistency, and variable film quality. Small format cameras can be used in groups to acquire multi-spectral photographs at the same time. Thirty five mm and 70 mm originals can be blown up with minimal loss of resolution to produce usable paper prints.

The standard lens for large format camera has a 6 inch (150 mm) focal length (the distance from the plane of infinite focus to the center of the lens). Lenses (and indeed the whole camera) are carefully calibrated to insure that they meet photogrammetric criteria.

Small format lenses can have a wide variety of lenses, ranging from 28 mm to 135 mm focal lengths or more. The standard lens has a 50 mm focal length.

Film. Film consists of a light sensitive emulsion of silver halide crystals, a relatively thick base which provides stability, and a backing which reduces the tendency of the film to curl. When the silver halide is exposed to light the bond between the silver and the halide is weakened. Areas that are not exposed to light remain the same. When the film negative is developed areas that were exposed to intense light turn to free silver and become black; areas that receive no light become clear. The degree of darkness of developed images is a function of total exposure. A positive image is produced by repeating the photographic process in the darkroom onto white paper. Black and white film has a single emulsion layer, while color films have three emulsion layers that are each sensitive to a primary color. Color aerial films are known as reversal films because they are developed with a reverse process, which produces a positive original film. Prints from color aerial films are contact prints (are developed in contact with the original transparency rather than by projection).

Films commercially available today are: 1) panchromatic films, 2) IR films, 3) color films, and 4) color IR films.

Panchromatic films are black and white films sensitive to red, blue, and green light. These films are intended for photogrammetric uses which require very high resolution, or for low light applications, or for general reconnaissance.

IR films are black and white films sensitive to the near visible IR portion of the EMS, as well as visible light. These films have superior haze penetrating ability, show good contrast between land and water, and can differentiate between various vegetation types.

Color films are sensitive to the visible portion of the EMS and record objects on colors complementary to their natural colors. Resolution is generally not as good as black and white films, but it is easier to recognize objects on the ground. See Figure 5 below for the color sensitivity of color film.

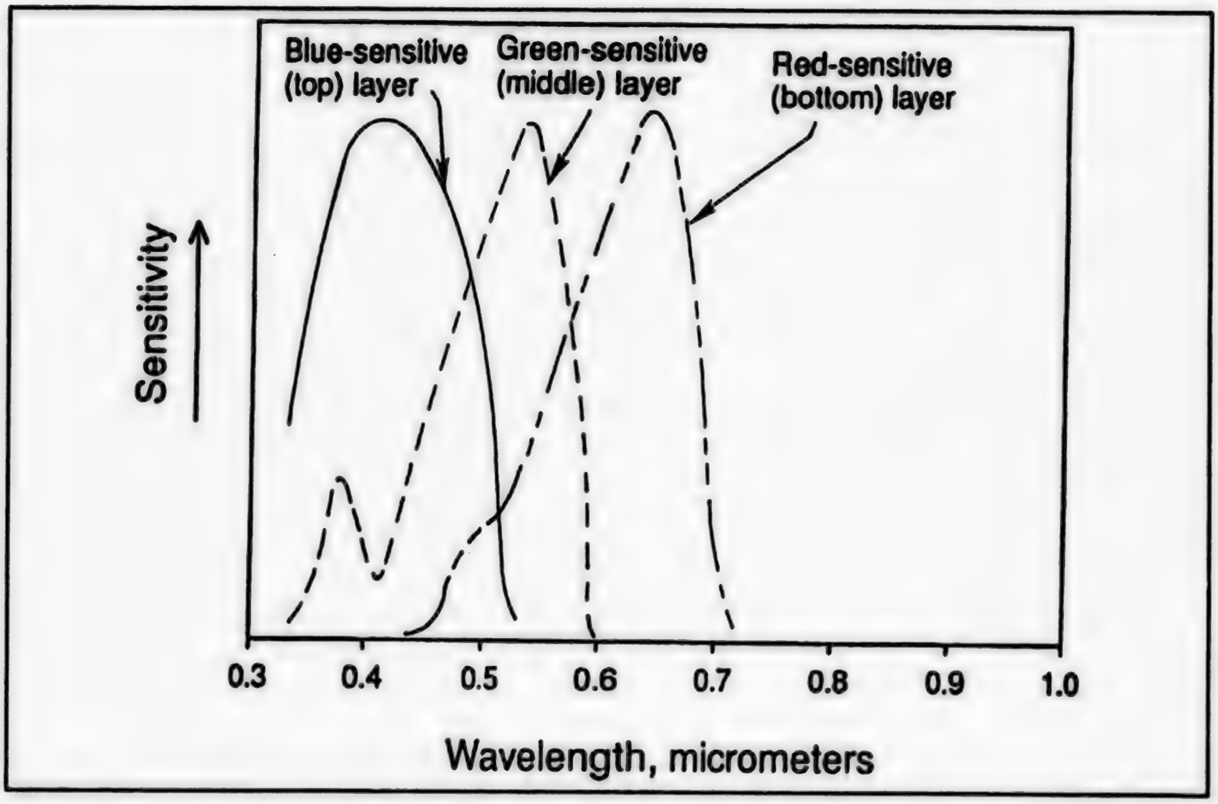

Figure 5. Sensitivity of Color Film

Color infrared (CIR) films are sensitive to the visible as well as the near visible IR portions of the EMS. A yellow filter, which blocks blue light is attached to the lens. Blue EMR is blocked, green EMR become red, red and IR EMR becomes blue. Because spectral reflectances for green vegetation are generally higher in the IR portion of the EMS, more data captured by the photo image, and difference in vegetation color appear larger. Also CIR film has better haze penetrating capabilities than color film does. The major disadvantage of CIR film is the unfamiliar color of objects; this requires time to learn new colors. CIR film is heavily used in plant sciences, and is especially useful for distinguishing types of wetland vegetation. See Figure 6 below for the color sensitivity of CIR film.

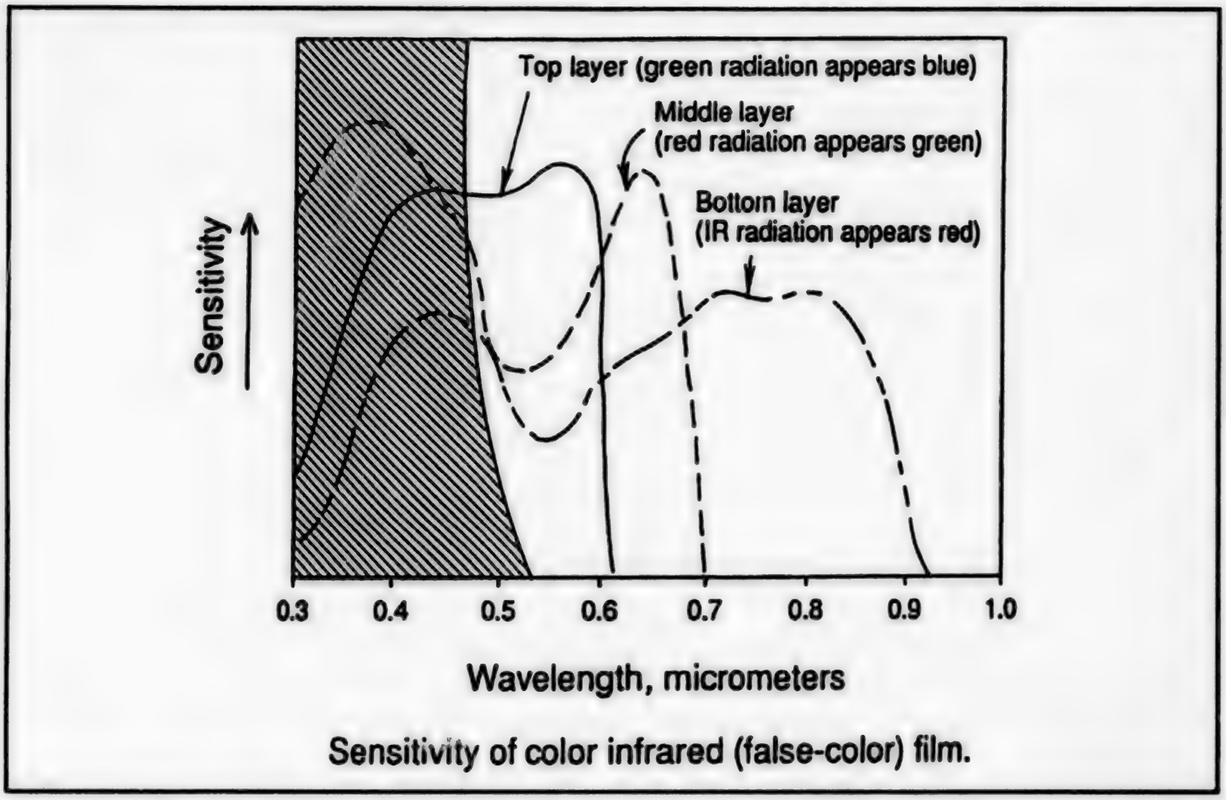

Figure 6. Sensitivity of Color Infrared Film

SCALE

Aerial photography can be divided into oblique and vertical photography. Oblique photographs are taken with the camera's optical axis at an angle to vertical. Oblique aerial photos show objects in more easily recognized form and afford larger ground coverage than do vertical photos taken from the same altitude. These photos are valuable for reconnaissance and planning as well as producing dramatic pictures.

Vertical photographs are taken with the optical camera axis vertical. Small tilts from the vertical are invariably present; for mapping purposes tilts of less than 1° are acceptable.

Vertical photographs produce a reasonably uniform scale, which the ratio of a photo distance to the corresponding distance on the ground. On a map, scale is everywhere consistent, but on a photo, scale varies with variations in terrain elevation.

Scale may be expressed as:
1) Unit equivalents: 1 inch = 1,000 feet
2) Dimensionless representative fraction: 1/12,000
3) Dimensionless ratio: 1:12,000

When we talk of large scale, we mean that objects on the photo/map appear large (e.g., 1:1,000). Small scale refers to scales where objects appear small on photos/maps (e.g., 1:100,000).

Scale may be represented by:

$$S = ab/AB = f/H'$$

where:
S = scale
ab = photo distance
AB = corresponding ground distance
f = focal length of camera
H' = flying height above the ground (AGL); H' = H - h where H is flying height and h is elevation of ground.

On flat terrain, such as the Mississippi valley, scale may be considered uniform over the entire photograph (assuming the plane was level when the photo was taken). Over more rugged terrain, such as the Rocky Mountains, scale may vary tremendously within a single photograph (Figure 7).

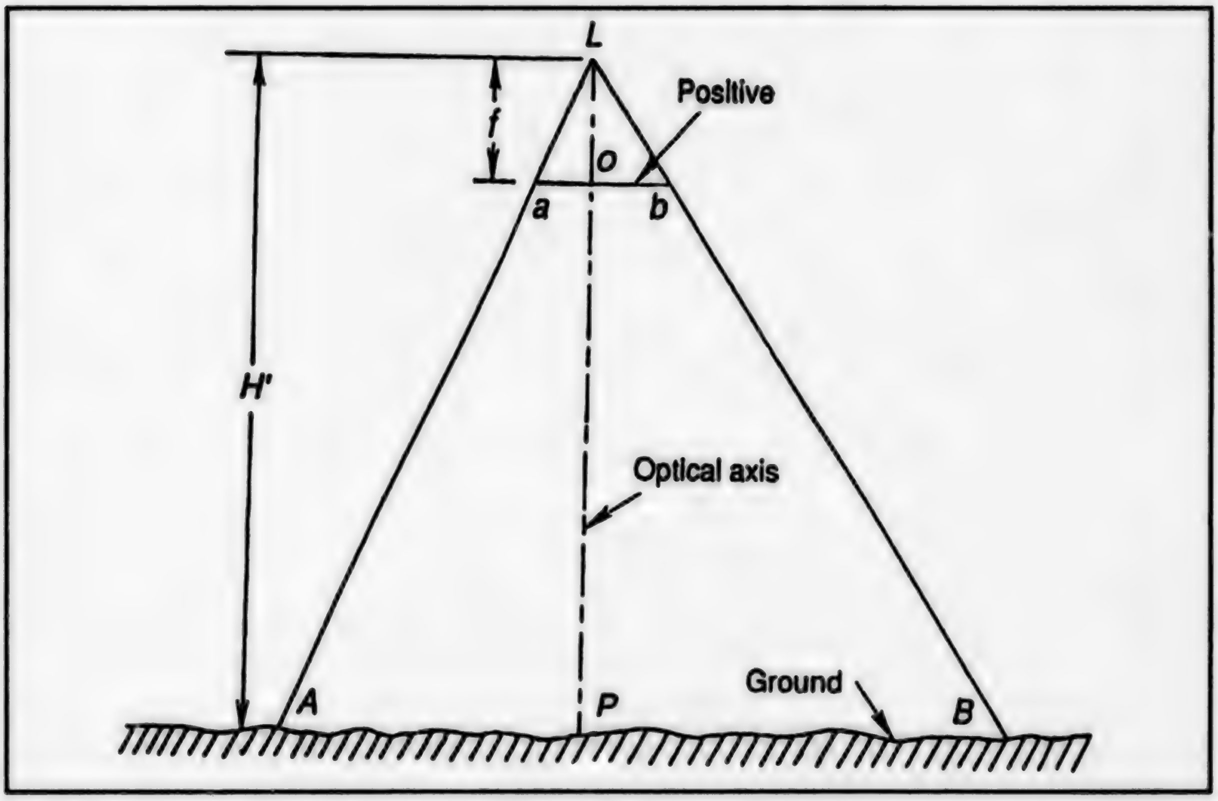

Figure 7. Scale of Vertical Photography

Another way to determine scale is to compare photo distance with the corresponding distance on a map of known scale. Scale can be calculated from the following equation:

S = photo distance/map distance x map scale

Exercises: Scale

1) A vertical aerial photo is taken over flat terrain with 6 inch focal length from an altitude of 6,000 AGL. What is the photo scale?

2) A section line lies on level terrain. Find the approximate flying height above the terrain if the camera focal length is 3.5 inches and the section line is 3.7 inches on the photo.

3) The photo distance between two image points a and b on a vertical photograph is 3.68" and the corresponding ground distance is 5,853'. What is the photographic scale?

4) The problem is the same except that the photo distance is 52.8mm and the ground distance is 3,875'

5) A vertical photograph was taken with a camera having a 6" focal length, from a flying height of 8,000' above sea level. If the ground was 1,250 above sea level, what was the photo scale.

6) On a vertical photograph the length of an airport runway measures 6.30". On a map which is plotted to a scale of 1:24,000, the runway measures 4.06". What is the scale of the photograph?

7) A 35mm aerial photo slide is taken at a height AGL of 1640' with a 50mm focal length. The photo is then blown up 8 times. Calculate A) the original slide scale, B) the resulting print scale.

8) Two 9" x 9" aerial photos cover an area. On photo's scale is 1:10,000 and the other photo's scale is 1:20,000. A) How many miles on the ground will each photo's width cover? B) What is the area each photo covers in square miles? In acres?

USES OF VARIOUS SCALES

The larger the scale of a photo, the smaller the coverage area. An example of this was the scale exercise 8. A 1:10,000 scale 9" x 9" photo covers a path 1.42 miles wide, while a 1:20,000 photo covers a path 2.82 miles wide. The 1:10,000 scale photo has more detail for a given resolution that does the 1:20,000 scale photo, but it covers a smaller area; this is a trade-off for all areal photography. As one can see from exercise 8, doubling the scale from 1:10,000 to 1:20,000 increases the coverage 4 times. The converse is also true. To cover a given area at a scale of 1:10,000 requires 4 times as many photos as does the 1:20,000 scale.

Large scale photography[1] (under 1:10,000 scale) is used for detailed analysis of small areas (from 1 acre to a few square miles), as well as sampling points in a larger project area. 9" x 9", 35mm, and 70mm formats are used for large scale photography. Objects that are 1 foot or less in diameter are discernable. The transect photos we will be working with are an excellent example of large scale photography. Some specific applications are:

-Mapping tree seedlings in a nursery or planting
-Mapping grasses
-counting people for outdoor recreation activity
-measuring tree parameters
-detailed photogrammetric mapping

Medium scale photography (1:10,000 to 1:64,000 scale) are used for fairly detailed mapping and analysis of large scale project areas (up to thousands of miles[2]). Objects that of 1 to 6 feet in diameter are discernable. Individual trees and large shrubs can be identified under magnification. Applications include:

-Landcover/landuse mapping for UMRS
-Large area forest type mapping (e.g. a National Forest)
-Rangeland surveys
-Vegetation surveys of a county
-Land use of metropolitan area
-Recreational surveys of vehicles or boats
-Soil surveys

Small scale photography (over 1:64,000 scale) includes high altitude aerial photography, as well as satellite imagery. Objects over 6 feet in diameter are discernable at 1:64,000. Individual trees and houses are can not be identified; only generalized land covers. Applications include:

-State, national, or global monitoring of general vegetation, landcover, or geological resources.

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[1] The definitions in this section are not hard and fast. Every author has his/her cut-off for the difference between large, medium, and small scales. As the technology has grown to embrace high altitude aircraft and satellites these definitions have changed dramatically.

MEASURING AREAS

The size of areas on photos or maps may be of interest. If an area is a geometric shape, such as a circle or a rectangle, the area can easily be measured and calculated by lines. However, if the area is a polygon, it must be measured by other means. If one does not have a GIS handy to automatically calculate areas, here is a quick method to measure areas off of photos and maps. This is a dot grid, and if used correctly, can be fairly accurate. The technique is to place the dot grid over the area of interest in a "random" manner, secure it in place, and count squares and dots. The way to calculate the number of acres per dot is as follows:

ACRES

1) Determine the unit equivalent scale in inches/feet
2) Square the unit equivalent scale so 1 inch^2 = X feet^2
3) Divide X feet^2 by 43,560 feet^2/acre to calculate acres
4) Acres divided by dots/inch^2 equals dots per acre.

Exercises: Photo Measurements

1) Select a transect photograph that has a easily recognized feature, such as a road or an island, on the quad map. A) What is the width and length of the photo? B) The original negative was 24mm x 36mm; how many times was the negative blown up to the print? C) The original photos were taken with a lens that had a 35mm focal length and the plane had a nominal altitude of 3,660' AGL; what was the nominal scale on the original photo? D) What is the nominal scale of the print? E) Find two points on the map and photo and determine the actual photo scale? Does it match the nominal scale? What are sources of error?

2) Find points A,B,C,D as marked the Clinton NW quad on B&W print 95. A) Measure the photo distance and map distance AB and calculate the ground distance and photo scale. B) Measure the distance BC and calculate the ground distance. C) Assuming ABCD is a rectangle, calculate the ground area in acres.

3) Using the dot grid provided, calculate the number of dots per inch for the scales 1:15,000 and 1:24,000.

4) Measure the area ABCD on photo 95.

5) Measure the area of Stamps Island on the Clinton NW quad.

6) Determine the dots per inch for the transects. Measure a discrete area on a photo.

STEREO VIEWING OF AERIAL PHOTOS

Normal human vision, with two eyes, is stereoscopic, which allows depth perception, so we can see in three dimensions. We can see in binocular vision because our two eyes see an object at two different angles, and the brain automatically and unconsciously associates the object's distance with the angle. Objects can be seen in three dimensions between 10 inches and 2,000 feet from the eyes.

We can also see in three dimensions on aerial photos because of photo overlap. Aerial photos are normally taken with 60% end lap (photos in a flight line overlap 60% on end (Figures 8 & 9)).

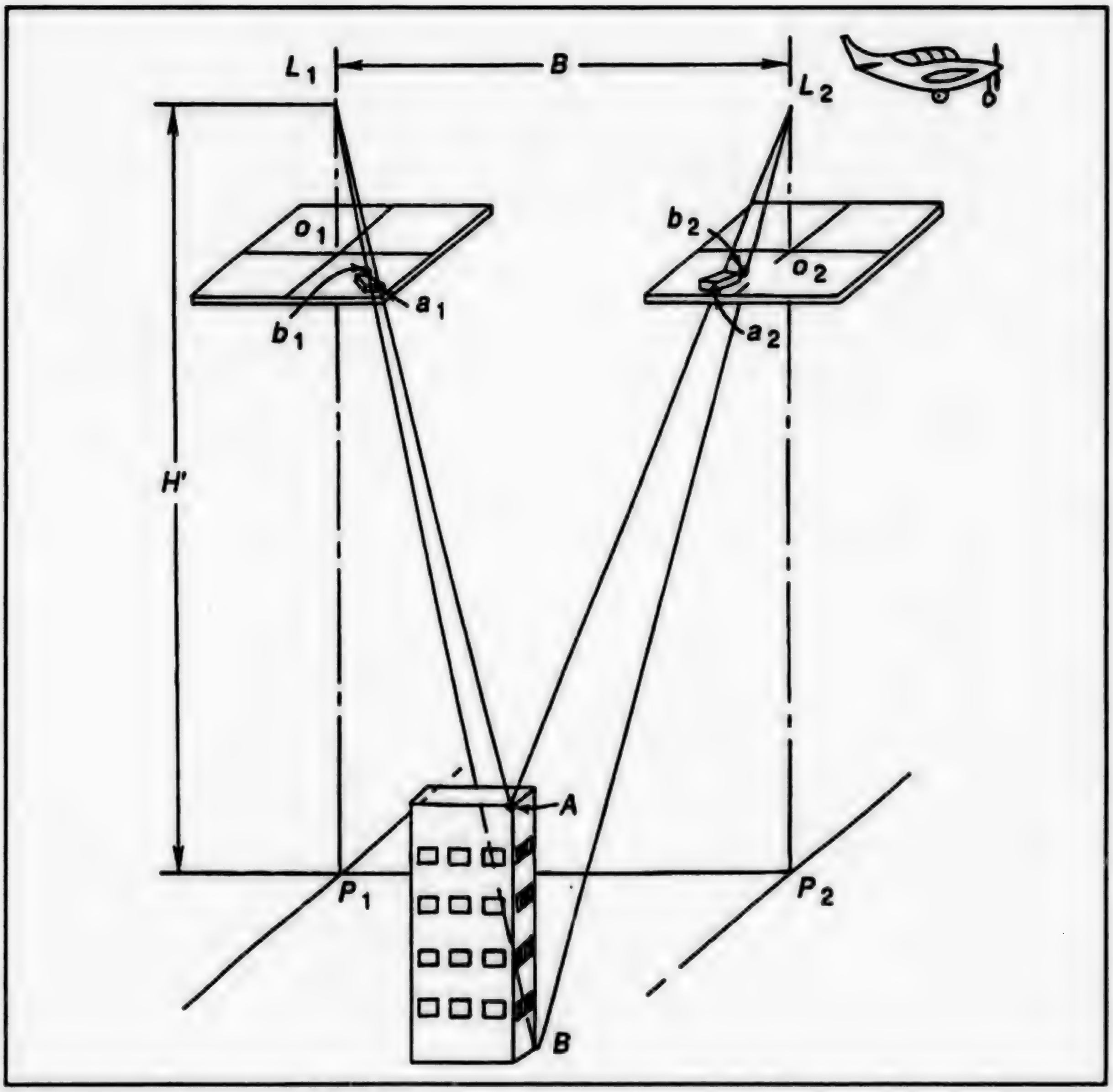

Figure 8. Photographs from two exposure stations with building in common overlap area.

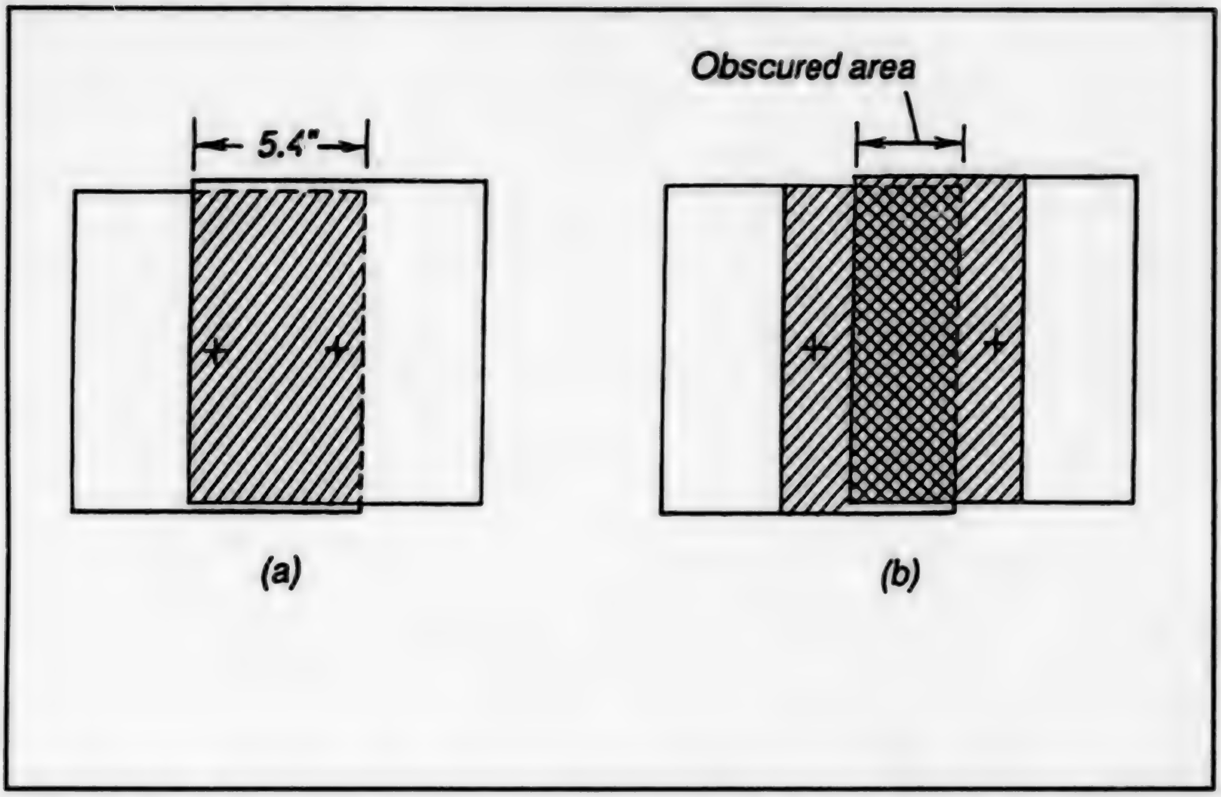

Figure 9. The common overlap area of a pair of 9-inch format photos taken with 60 percent end lap (corresponding images coincident). Obscured area when photos are oriented for viewing with pocket stereoscope.

To view 9" x 9" photographs in stereo, place the photos so that corresponding images are about two inches apart, place the pocket stereoscope on the photos, and then adjust the photos until the images fuse.

Exercises: Stereo Viewing

1. Look at photo pair 95 and 96 under the pocket stereoscope. Find points 1 and 2. Which is higher? What is point 3? What are the dark fuzzy things to the left of point 3?

2. Look at two of your transect photos in stereo.

3. Look at the dark red areas on the CIR stereo pair 64-17 and 64-18. Are these areas higher or lower than the surrounding lighter red areas?

4. Look at the stereo pair of color pictures. Place the points A,B,C in order of highest to lowest. Which point is higher, D or E; F or G.

OTHER USES OF AERIAL PHOTOS

A major use of aerial photographs is for photogrammetry. All the topographic maps produced by the USGS are made using aerial photographs in conjunction with ground control. The old survey maps of the River from the 1890's were all done by ground surveying, which was an incredible amount of work. Now with photogrammetry, large areas are mapped with aerial photographs, using stereo compilers. Ground points are surveyed for elevation, distance, and direction from known ground points. These points are found on the stereo pair of vertical photos, and then topographic lines are traced along contours, along with other map features. This is the application which requires precisely calibrated cameras and lenses. Topographic maps are compiled by the USGS for topographic mapping, highway departments compile maps for highway construction, and private engineering firms compile maps for construction projects.

Another major user of aerial photography is forestry, which was a disciplines which pioneered many applications for aerial photography. Forestry is concerned with the management of large, remote tracts of land, and aerial photography is the best way to gather information about those tracts. Specific uses include forest stand mapping, volume surveys, insect and disease surveys, forest fire mapping, and road layout.

Agriculture is a major user of aerial photography. The ASCS uses aerial photography and satellite imagery to track plantings for crop subsidies. CIR photography is used to detect insect and disease damage. Soil surveys are done with aerial photos in conjunction with ground work, as are range assessments.

Although geology may have taken advantage of non-photographic remote sensing technologies, such as SLAR, aerial photography is still valuable. Landform analysis, lineament mapping, oil and gas exploration are major applications.

Fish and wildlife disciplines use aerial photography to a great extent. Vegetation mapping, habitat analysis, surveys of large animals, fisheries habitat mapping are a few examples.

ACQUISITION OF AERIAL PHOTOGRAPHS

Although some projects may require flying new photography especially for their own use, this is expensive. Frequently, existing photography exists that may meet requirements. Below are a few sources of existing photography:

National Cartographic Information Center (NCIC)
Mid-Continent Mapping Center
USGS
1400 Independence Road
Rolla, MO 65401
(314) 341-0851

The NCIC has microfiches which contain listings of aerial photo coverage by state which was provided by major users of aerial photos such as the ASCS and the Forest Service.

User Services
EROS Data Center
Sioux Falls, SD 57198
(605) 594-6151

EROS has remote sensing data form Landsat and aircraft acquired by Department of Interior agencies.

Aerial photography may also be borrowed (sometimes) from local offices of state or federal agencies, such as the ASCS or the Forest Service.

INTRODUCTION TO PHOTO INTERPRETATION

DEFINITION

Aerial photo interpretation (PI) is defined by the ASP as: "the act of examining photographic images for the purpose of identifying objects and judging their significance".

The best photo interpreters are specialists in their area with a great deal of field knowledge because it is easier to learn photo interpretation than it is to learn a whole new science. A good photo interpreter is curious and observant about the total environment in which he or she works, as well as being perceptive about the many clues on the photograph which will reveal important facts about the environment.

PI is a deductive process which begins from features that can be identified, which lead the interpreter to recognition of other feature in the landscape. It is important to recognize landforms and terrain as the basic step in PI for both the beginner and experienced interpreter. Once the terrain is analyzed, then other facets, such as vegetation, hydrology, man-made features, will be identified and their significance recognized. Proper consideration of all aspects of a landscape, even when the interpreter is only concerned with one portion of the terrain, such as vegetation or geology.

The other requirement to becoming proficient interpreters is good eyesight. This means having normal color and depth perception and good acuity.

PHOTO PREPARATION

Indexing

Aerial photos must be organized and prepared before interpretation can begin. The first step is to determine what area the photos covers on a map. Often, the organization the does the aerial photography will create an index map which shows how the photos were taken, but sometimes no record exists and it is necessary for the interpreter to index the photos.

Indexing is also an indispensable first step when receiving photos. The flight index is a small scale map showing generally where photos lie. It is critical to carefully index all photos on a 1:24,000 quad map to make sure that there are no gaps in coverage, that the photos reach to the project boundaries, that the endlap and side lap is sufficient, and that the flight paths were reasonably straight. Do not accept aerial photography until one has carefully indexed it. To much coverage is acceptable, gaps in coverage is not acceptable

Before we go any further it is necessary to discuss the numbers, letters, and markings that are printed on aerial photographs. When aerial photos are flown, generally they are flown in a straight strip for a narrow area, such as the transects, or in a grid for a wider area, such as the Mississippi valley. The letters are printed on the leading edge of the photographs; that is, the aircraft was heading in the direction of the lettering. The numbers in the upper left hand corner represent the date the photos were taken. The numbers and letters in the upper right hand corner represent the exposure number, perhaps the strip number, and perhaps the roll number. Other lettering in the middle may represent the project code, the agency flying the photography, and the scale. In the corners and on the middle of each side are fiducial marks. These are for registering overlays to the photo, so if there is slippage, or the overlay is removed and replaced, it can be placed exactly where it was before and all delineations match the photo.

Exercises: Photo Indexing

1. Take a strip of photos and mark the center of where each photo lies on the quad map along with its number.

2. Take another strip of photos and sketch where the edge of each photo lies on the quad map along with the photo number. How much is the endlap? Were the photos flown in a perfectly straight line? What could contribute to deviations from the flight path?

PREPARATION FOR PI

Now that we know where the photos lie on the map, we have to prepare the photos for PI. Writing directly on photos is not a good idea, because 1) the writing obscures the image, 2) if a mistake was made wiping off the writing often damages the emulsion, 3) the photo cannot be used easily for other purposes, 4) and writing on photos with pencils or grease pens does not produce fine lines. Using clear plastic overlays registered to the photo and delineating with fine tipped drafting pens overcomes these problems.

The first step is to create fiducials with a drafting pen and if necessary number the photos (the one exception to the rule of not writing on the photo):

-Take the straight edge, place it over the corners of the photo, and draw 1/2" lines in each corner.

-Then put the plastic overlay, cut to size, on the photo and secure in place with tape.

The next step is to create the work area or effective area on the overlay. The center part of the photo is spatially the most accurate portion of the photo, so the work should be as close to the center as possible:

-Place one photo over the adjacent photo in the flight strip, find the halfway point of the overlap, and draw a line on one photo marking this overlap.

-Using the stereoscope, find matching points along the line on the other photo, then connect these lines with a straight edge.

-Repeat the process on all sides of the photo that have adjacent photos.

-On photos that are at the project area's edge, trace the project boundary on the photo. Continue this process until all photos have a closed work area on the overlays.

Exercises: Photo Prep

PREPARE A STRIP OF PHOTOS AS DESCRIBED ABOVE

Signature

Signature is the characteristic appearance of an object on a given type of imagery. Obviously for vegetation, signature is going to vary greatly according to time of day, time of season, type of photography, and scale. Within a type of photography, signature is affected by the following factors: Color/tone, texture, pattern, shape, size, location. Often the factors will not aid in identifying an object when considered singly, but taken in combination, these factors will lead to proper identification. For example, two vegetation types may have the same color and texture, but they are found in different types of locations, or two vegetation types may be found in the same habitats, but will have different colors. It is important to learn the combination of factors which distinguish one type from another.

Color/Tone

Tone is the shade of gray in B&W photography, while color is the combination of hue, chroma, and saturation in color photography. These two factors usually convey more information to the interpreter than anything else. The human eye can distinguish 100 to 200 shades of gray, while it can distinguish thousands of different color. It is for this reason that color and CIR photography is far superior to B&W photography in vegetation identification.

Vegetation types usually have a characteristic color at a given time of year on a given type of photography. Color can be greatly affected by the background against which it is seen, or by the density of the vegetation, or by the physiological state the vegetation is in. For example, on CIR lotus has a characteristic red color in water over one foot deep, which appears black. However, when duckweed, which appears white is present, the background contrast makes the lotus appear darker.

Texture

Texture is the composition and arrangement of small constituent parts of an object. Texture may be characterized by such terms as smooth, uniform, velvety, or rough. Planted vegetation usually appears smoother than natural vegetation, although large, uniform stands of wetland emergents may appear smooth. Differences in height produce rougher textures, such as a stand of reed canary grass, which falls over and lodges in clumps, produce a fairly rough texture, as does shrubs mixed in with forbs.

Pattern

Pattern, or repetition, is the characteristic arrangement of objects. Some types of vegetation have highly recognizable patterns which aid in their identification. For example, lotus and lily, which are otherwise very similar, have different patterns. Lotus appears in a random pattern, while lily has a pattern of small clumps. Lands that have been cultivated retain the plowing patterns for years after they are fallowed. Cultural features usually have a regular pattern.

Shape

Objects' shapes may be difficult to recognize form the vertical perspective of aerial photography. The shape, or form, of objects should be considered in the following ways: Regularity of form; geometrically shaped objects are often man-made, the presence or absence of a regular shape, relative proportions of height to width and/or length. Shadows may often be used to determine the shape of an object, such as trees.

Size

Some objects are readily identifiable and can be used as guides to determine the size of other, not so readily recognizable objects. Relative size may be critical in identifying objects, such as a shrub versus a tree.

Location

Location covers a wide variety of factors such global location, ecological site, and association with other objects.

Global location. Since the UMRS is located in the upper Midwest of the U.S. the probability of finding mangroves or palm trees is fairly remote; the choice of vegetation species that are found here can be narrowed significantly.

Ecological location. Lotus will not be found 200 feet up a bluff on the side of the river valley; conversely, sand prairie species will not be found in backwater areas. But to use a more realistic example, the gradation of water depth requirements that aquatic species such as lotus, arrowhead, cattail, burreed, and rice cutgrass have can be used to identify these species. For example, arrowhead is generally found in slightly shallower waters than is lotus, and should be closer to shore when found in conjunction with lotus.

Association with other objects: Aquatic plants are usually associated with water, agriculture is usually associated with roads and trails, and athletic fields are usually associated with high schools.

IDENTIFICATION OF OBJECTS AND SIGNATURES

Exercises: Photo Identification

1. Color photos 31-15: a) what are the two curved objects? What are they made out of? Are they man made? b) what is the light brown material? How did it get there? c) where and when were these photos taken?

2. B&W photo 1173 161: a) When were these photos taken? What is the scale? b) what is the complex at b? What is the complex at c?

3. CIR photo 85-56: a) When was this photo taken? b) What are the red and white circles on this photograph, why are they red or white? c) What are the blue areas, why are they blue? d) Where was this photo taken? e) If the circle at pointer e is 2,417' what is the scale of the photo?

4. B&W photo 62-35: What is the scale of this photograph?

5. CIR photo 22-11: a) When and where was this photo taken? b) What is the complex at b? How do you know? c) What is the complex at c? d) what are the dots at d and e? e) What are the bands of vegetation at f and g?

6. B&W photo YE-3B-20: a) when was this photo taken? b) assuming the distance between a and b is 1 mile, what is the photo scale? c) what are the objects at c, d, and e? d) where was this photo taken?

7. Color stereo pair 31-16, 31-17: Set up and view under your stereoscope. a) When and where were these photos taken? b) Identify vegetation types a - f.

8. CIR stereo pair 7-89, 7-88: Set up and view under your stereoscope. a) where and when were these photos taken? b) Identify vegetation types a - c.

GROUND TRUTH

Importance

Ground truth is essential to aerial photo interpretation. Without ground truth the classification of cover types would not be accurate and the whole process would be an exercise in futility. It is imperative that the interpreter be very familiar with the area being interpreted, as well knowing the specific objects being classified. That is why experienced field people make the best interpreters; they are the most knowledgeable about the area being photographed.

Considerations

There are two basic reasons for ground truthing: 1) familiarization with the area, and 2) verification of interpretation.

Familiarization: Familiarization must be done by the interpreter; others may assist him or her, but the interpreter must get out on the ground and see the sites for himself/herself. The best procedure is to initially scan the photographs and find areas that present questions that are easily accessible by car or boat or foot. Also find easily accessible major signatures and cover types. Mark potential field sites on a 1:24,000 quad along with pertinent questions about the sites in the margin. Travel to the area and locate the areas on the ground. A field form such as the one in Appendix 1 is helpful in prompting the interpreter to ask and answer all pertinent questions. Take careful notes about the location of the site, its size, major species composition and mixture, percentage of each species, etc, and make good sketch maps. Remember to take copious notes because too much information is better than not enough information and it is hard to go back to the field in January to determine the composition of an aquatic bed. Ground photographs are very helpful to prompt the memory about the site when back in the office. Once back in the office carefully review the field note to make sure all initial questions were answered.

Then begin PI. Questions invariably arise as detailed analysis of the photos proceeds. Mark these further questions on the maps, then when the PI is 1/3 to 1/2 complete take a second field trip to answer these questions. Detailed field notes are not usually necessary as in the first trip. Brief notes taken on clear plastic sleeves registered to the photos may be sufficient at this point.

For a project of limited size, such as one restricted to one pool, two field trips should be sufficient to visit all major cover types. For a larger project, such as mapping the portions of the entire UMRS more field trips are necessary, because conditions and vegetation changes dramatically over long distances. Spending a little time and money to travel to the site pays of in big returns down the road by increasing accuracy and forestalling problems.

The second type of ground truth is verification of completed interpretation. This is the stage where mapping has been completed and sample cover types are visited to verify if they were mapped accurately or not. This can be done in a statistical manner, which will create confidence intervals for the accuracy of the mapping.

CLASSIFICATION SYSTEMS

Significance

In order to map an area a classification system is necessary. There are as many classification systems as there are mapping projects; every one is different, and every one more or less serves its purpose. Classifications range in scope and complexity from global one such as Bailey's Ecoregions to national ones such as Cowardin's NWI system to local systems. They all have on major drawback in common; they attempt to put nature, with its ever changing complexity, into neat classes. While some cover types may fit perfectly well into classes, many do not fit neatly into classes.

Minimum Mapping Unit

Minimum mapping unit (MMU) is the smallest polygon that will be delineated during interpretation. MMU is determined by the scale of the imagery, the size of the project, and the project's requirements. The larger the imagery's scale and the more detailed the data required the smaller the MMU. If the photo scale is 1:80,000 and forest stands are being mapped for a national forest, the MMU may be 40 acres. If the photo scale is 1:15,000 and key pools of the UMRS are being mapped for vegetation/landcover, then the MMU is as small as the interpreter can delineate, which is about 0.1 acre.

Stratification

Aerial photo interpretation and mapping can greatly enhance the statistical accuracy and efficiency in vegetation sampling efforts. Delineation of discrete vegetation places the vegetation into homogenous classes or cover types, which is called stratification. Ground sampling efforts, for whatever variable, such as number of stems per square meter, can than be concentrated into the cover types of interest. If all cover types must be sampled, the number of samples to reach a required precision is lowered because the cover types are homogenous and have less variation within the cover type than throughout the entire project area. A relatively few samples from representatives of each cover type will produce the necessary precision, rather than a large number of samples from the project area as a whole.

Then once the samples are taken they can be extrapolated over the entire project area for that cover type. For example, the sampling indicates that in Cover Type 1 there are 200 silver maple trees per acre, while in Cover Type 2 there are 80 maple trees per acre. Cover Type 1 covers 50 acres, while Cover

Type 2 covers 200 acres. We can then extrapolate that there are 1,000 maple trees in Cover Type 1 and 1,600 maple trees in Cover Type 2.

Cartography

What do we do with the data when the photo interpretation is completed. As we know, a photo is not an accurate representation of the earth's surface. Is the data good enough to be used as is. In some cases it is. If all we want is a rough idea of where cover types are on the ground, no further processing of the photos is necessary. But if we need to derive reasonably accurate area measurements (but not to photogrammetric precision), or compare changes in cover types over time, it is then necessary to transfer the data to a base map.

Transfer is done using a transfer scope, which allows the operator to superimpose both the photo and the base map into view. Zoom controls allow the operator to change the scale of both the photo and base map so they are the same scale. Other controls allow the operator to stretch the photo to eliminate distortions. A skilled operator can transfer data from photos to base maps in a highly accurate manner. Once the data is registered to the base map, other themes can be compared directly with the data. For example, several different years of vegetation cover mapping can be directly compared, or the effects of topography on vegetation can be analyzed.

If the project is large and complex, it may be necessary to automate the data into a computerized geographic information system (GIS). This is a highly technical and tedious process which requires much labor, but once the data is automated the analytical possibilities are endless.

PHOTO INTERPRETATION WORKSHOP

PERSPECTIVES OF A RIVER RAT (R. Vose)

Handling Troublesome Areas

The concept of boundaries. As we already discussed under the classification section, it is not always easy or clean to place the complexities of nature in a neat box. The same holds true for boundaries; one vegetation type may merge imperceptibly into another type. Where do we put the line?

Some boundaries, at first glance anyway, are clear cut. For example, the land - water boundary, or the forest - non forest boundary appear to be sharply defined. These may be clear at a given point in time, but will change over time. The change for the land - water boundary on the river can change over night, and certainly changes over the course of a year. The forest - no forest boundary will change over the course of years. In these cases, draw the line where it appears on the photo.

Other boundaries are not clear at all. In aquatic areas, where the composition of vegetation is controlled by water depth, which changes very gradually over an area, fingers of one type merge into another. There is a tension zone where the two types are mixed. Where do we put the line? For example, Class A merges into Class B and there is a tension zone AB between them. If the interpreter has been concentrating on Class A he or she will draw the line where Class A changes into tension zone AB, or vice versa. The line could be drawn halfway between A and B in the middle of AB, or lines could be drawn between A, AB, and B. There is no one best solution, the answer depends on the specific situation. One thing is inevitable, however. No two interpreters will ever draw the lines the same, no will an interpreter draw the line the same way twice.

Areas of mixed vegetation. There are several ways for handling mixed areas. The easiest way is to create a general mixed vegetation class, which would include all non pure areas of vegetation. A second way would be to create specific mixed classes: if species A and species B each cover at least 30% of the area (for example), then it will be type AB. Another way is to use a rule of thumb based on dominance: if species A covers 50% (for example) or more of the area, it will be called that type no matter what else is there. Another way is to create hierarchy of vegetation. A common hierarchy is to place woody vegetation over herbaceous vegetation. If a meadow of reed canary grass merges into a stand of trees, call the forested area forest if the trees cover at least 10% (for example).

Areas that can't be identified on photos. Unidentifiable areas are the interpreter's nightmare. They are a result of either 1) very complex and variable vegetation that was photographed over a large heterogenous area and over a long time by different photographers, or 2) inadequate field work. How do we handle them? The ideal answer is to ground truth the unknown areas. What if this is not possible? What if the interpreter is 1,000 miles away and it is the middle of winter and the area is frozen over? There are two approaches: 1) the interpreter admits that he/she does not know what the area is and calls it "unknown" and perhaps the area can be visited next growing season, or 2) guess.

Guessing is not as bad as it sounds, if done in the proper manner. The proper way to proceed is delineate all the areas that are easily identified, then proceed to the questionable areas. Often what happens during this process is that the interpreter will learn that the identifiable areas merge into the unknown areas, and that the unknown signatures are variations of known signatures. Or, if the area is still unknown after this process, eliminate the impossible, which leaves the probable; narrow the possibilities to what may occur in that niche, then make the best educated guess possible. Interaction with other interpreters is invaluable in this process to get a fresh perspective. Often an experienced interpreter who takes a fresh look at an area will be able to clear up the question immediately. Taking a break and returning to the area the next morning is also valuable.

DRAWING AND LABELING POLYGONS

It is important that delineation and labeling be done in a neat, legible manner. Drafting pens can sometimes be balky and uncooperative, so keep them clean, change the ink periodically, and do not drop pens on the floor. Lines should be of uniform width and follow the ground features on the photo closely. Polygons must be closed. When finishing one photo and beginning another, match all lines and labels between photos so they are consistent (including side lap). Make sure all polygons are labeled, that polygons only have one attribute (multiple labels are fine in large, complex polygons, but they must be the same attribute), and that adjacent polygons have different labels. Overly complex delineation that is difficult to read and decipher is not acceptable. Lines leading from labels into small polygons are acceptable. A good check when the interpretation is done is to place a clean sheet of white paper between the overlay and the photo and check for completeness of delineation and labeling, as well as other common errors listed above.

WORK ON YOUR OWN PHOTOS

We will begin working on our own transects this afternoon and tomorrow morning. It is not certain how far we will get, but the objective is to do some preparation and interpretation so the instructors can review and comment on it before the session ends. The instructor wants the participants to feel confident that they can do a professional job of PI when they return to their stations.

DILBERT by Scott Adams
MAYBE TOM CAN EXPLAIN TO THE FIELD PEOPLE HOW THE SYSTEM WORKS.
UH-OH.
UM... SO THE ELECTRONS ALTER THE DATA BITS... AND THEN THEY GO TO THE VIRTUAL ARRAY WHERE THEY CONFLUGALIZE.
GOT IT?
HOW MANY OF THOSE WORDS DID YOU JUST MAKE UP?
THEY'RE ON TO ME.

APPENDIX 1

UMRS FIELD SHEET

REPORTED BY____________________DATE______________SITE NO.____________

OTHER PARTY MEMBERS____

____

____

GENERAL SITE DATA

AERIAL PHOTO: NUMBER___________DATE________TYPE________SCALE________

U.S.G.S. QUAD_____________STATE____________CITY__________POOL________

TOWNSHIP______________RANGE______________SECTION____________

BRIEF DESCRIPTION OF SITE RELATIVE TO IDENTIFIABLE POINTS ON TOPO MAP

____

____

____

ATTACH XEROX COPY OF FIELD SITE FROM 7 1/2" QUAD

GROUND PHOTO DATA

ROLL	NUMBER	DIRECTION	DESCRIPTION

DETAILED SITE DATA

DESCRIPTION OF SITE____

____

____

DOMINANT PLANTS____

____

COMMON PLANTS____

____

LESS COMMON PLANTS____

____

INITIAL FIELD CLASSIFICATION (1) GEOMORPH____________________

(2) LAND USE/LAND COVER____________________

DISCUSSION OF P.I.____________________

____

____

FINAL PHOTO CLASSIFICATION (1) GEOMORPH____________________

(2) LAND USE/LAND COVER____________________

SOILS DATA____________________

____

OTHER OBSERVATIONS (WATER REGIME, WILDLIFE, GEOMORH, ETC), DISCUSSION

____

____

SKETCH OF FIELD SITE

APPROX. SCALE

NORTH
ARROW ☐

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0705-0188

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BSTRACT (Maximum 200 words)

orkshop's objective is to give Long Term Resource Monitoring Program field personnel training to use aerial photographs in their everyday work. By the end of the workshop, field nel will be able to use aerial photos to aid in locating where they are in the field, to help locate field plots and transects on base maps, to be able to identify and map objects and tion types on photos and determine photo scale, and to measure objects on photos.

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